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This article represents a preliminary attempt to conceptualize the relationship between technology and global inequality, using a political economy of the world-system perspective. Despite the crucial role that technical innovation and adaptation play in the process of international development, many macroanalyses of social change focus little explicit attention on technology. Only neoevolutionary theory discusses its role in long-term social change, and then in ways that miss some key dimensions. The author argues that technology is a social product designed to fit the needs of the rich and powerful. In the contemporary world, it is usually produced by a highly organized (and expansive) research and development (R&D) industry, often explicitly linked to military-industrial complexes. Rhetoric about increased globalization notwithstanding, technology is a key resource in the present capitalist world-economy that is very unevenly distributed, with the advanced industrial "core" states (and their giant transnational corporations) controlling technological innovation and dissemination. Even newly industrializing countries (NICs) like South Korea, which many consider technologically sophisticated, experience profound technological dependence, limiting their prospects for truly autonomous economic growth. Differential control of technology and technological innovation is a defining trait of global inequality in the late twentieth century.

Technology is a critical element in understanding the process of international development and world inequality. The unequivocal assertion of economic geographer Peter Dicken (1992) is widely shared and rings true: "Technological change is at the heart of the process of economic growth and economic development" (p. 97). But all too often social scientists, policymakers, and the general public assume that technology and its relationship

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to growth and international competitiveness is simple and unproblematic. In an area where even adequate definitions are difficult, unraveling the complex and slippery process whereby innovation takes place and is applied to products and processes is a major challenge. This complexity is compounded as contemporary science and technology operate in increasingly global arenas.

Most recent attention to the role of technology in the global economy focuses on the intense competition among the advanced industrial nations and their increasingly footloose transnational corporations for technological advantages at the cutting edge of innovation in science and engineering (e.g. Freeman 1987; Roobeek 1990; Porter 1990). Worldwide economic recession and restructuring have led to contentious debates among scholars, journalists, businesspersons, and political leaders about new strategies to maintain international competitiveness, particularly in high-technology research and production. There is little doubt that competition over technological innovation and application is fierce at the highest levels of the global system. And its basic nature is changing as "information technology" and "space-shrinking" advances in communications and transportation become more crucial (Dicken 1992, 101-10; see also Henderson 1989) and huge transnational businesses become less anchored to particular nation-states. This leads neoliberal economists like Robert Reich (1991) to argue that "high-value" technologically sophisticated businesses are the key to developing a successful national industrial policy in the United States.

Although the dynamic of technological and economic competition in the advanced industrial core nations is inherently interesting and increasingly relevant to public policy (for instance, Reich is a key economic adviser to President Clinton), this brief discussion will put these issues aside to focus on technology's place within the broader core-periphery structure of the world-system. I argue that technological dependence is an increasingly important mechanism through which advanced industrial core states and corporations maintain their positions of power and affluence in the global system. Third World "peripheral" or "semiperipheral" societies are almost invariably inserted into the world-economy far down the "product cycle" (Schumpeter 1964; see Cumings 1984 for a discussion). Usually, these countries possess indigenous research and development (R&D) capabilities that are severely limited. Their technology of production and infrastructure usually originated in the core but is often no longer used there. Table 1 documents the paucity of R&D in the non-Western "developing" countries.[1] That these societies lack highly profitable cutting-edge technological innovation means that they must either use less sophisticated machines and

Table 1. Distribution of R&D Expenditures by Country Groups (Percentage Of World Total)

Regions or Countries	*1970*	*1975*	*1980*	*1983*
Developed market economies	72.5	70.2	72.7	72.7
European Economic Community	20.3	21.6	21.5	20.9
Japan	6.7	9.5	11.7	12.6
United States	39.9	33.3	33.7	33.4
Socialist countries of Eastern Europe	25.2	27.1	24.4	24.2
USSR	19.4	20.9	17.6	18.0
Developing countries	2.3	2.7	2.9	3.1
World	100.0	100.0	100.0	100.0

SOURCE: United Nations (1987b, 78, Table 25). Original data from Organization for Economic Cooperation and Development (1986).

production processes or rely on foreign firms or expensive licensing agreements for access to technology. This is the essence of "technological dependence" (see Gereffi 1983), which has become a major obstacle to truly autonomous industrialization and development throughout the Third World in the late twentieth century.

Despite the critical role that technology clearly plays in establishing and perpetuating global inequality, world-system theorists pay surprisingly little attention to systematically explaining technological innovation and diffusion. Wallerstein (1974, 1980, 1989) discusses the importance of technological advantage and the way in which states and corporate actors nurture and protect them. Various theorists claim that the technology of production is a key element in differentiating between "core-like" and "periphery-like" production (Arrighi and Drangel 1986; Chase-Dunn 1980, 1988). But very little effort has been expended explicitly delineating the precise role that technology plays in the world-system. In this article, I try to present a preliminary sketch of insights that current debates in international political economy shed on science and technology as a global system. It is not my purpose to show global capitalism as the sole determining factor underlying the organization of science and technological innovation and diffusion. But I would argue that any theory purporting to explain science and technology as a global system will need to consider the degree to which it reflects the hierarchic and exploitative *uneven development* dynamic endemic to the current international system.

Traditional social scientific views of comparative international development tend to ignore this dynamic of the science and technology "deficit" in less developed societies. The most comprehensive attempts to delineate the

place of technology in social change are found in social evolutionary theory. Most fully elaborated is the neoevolutionary approach of Gerhard Lenski (1976; Lenski and Lenski 1987). According to Lenski, "advances in subsistence technology stimulate advances in other technologies and lead to growth in the size, complexity, wealth, and power of a society" (Lenski and Lenski 1987, 71). Certain types of subsistence technology lead to broadly similar types of social organization. Therefore, it is possible to present an "ecological-evolutionary taxonomy of societies" ranging from "hunting and gathering" through "horticultural" and "agrarian" on to various levels of "industrial." Although Lenski takes great pains to distance this approach from technological determinism, he clearly believes that technological innovation and adaptation are the "master trend" underlying sociocultural evolution. As his text demonstrates, this approach successfully accounts for a diverse sweep of anthropological and historical material—in effect, providing an elegant explanation linking subsistence technology to 40,000 years of social change. On the other hand, neoevolutionary theory is more cautious about predicting patterns and effects of technological change in the contemporary world (Lenski and Lenski 1987, chap. 13).

Other theorists and schools within the social sciences that identify technology as the driving force of socioeconomic development are much less careful. They range from pop social analysts like Alvin Toffler, writing loosely documented books embracing unabashed technological determinism (Toffler 1971, Toffler and Toffler 1990), to economists promulgating endogenous growth theory, in which variables measuring the rate of technological innovation are hypothesized to be significant predictors of social growth rates in econometric models (Romer 1990). Most of these discussions take economic development in the advanced industrial countries as their starting point, with only tangential interest in the dilemmas of Third World development. But their influence is pervasive, and their basic assumption—that societal technology level is the underlying factor on which the relative wealth of nations ultimately depends—is rarely challenged.

But these simplistic views that flirt with technological determinism are deeply flawed. First, taken to the extreme, they revert to stage theory, which suggests a unilinear evolutionary path for human societies—a view that has been widely attacked (see, e.g., Portes 1976). There is also a tendency to assume that technology "naturally" evolves in a "value-free" way and social forms follow. But we know that technology is a *social* product and that it is often designed to fit the needs of the rich and powerful (see Noble 1985). Finally, they tend to ignore or downplay the possibility of asymmetric, exploitative relationships between societies at different levels of development (i.e., the key insight of the world-system perspective). For these reasons,

most world-system and international political economy researchers are not very sympathetic to this widely accepted image of technological change and its developmental consequences.

What alternative approach to science and technology does the political economy of the world-system suggest? As I noted above, this has been something of a blind spot in the vision of major world-system theorists. It would be extremely pretentious to sketch out such a theory in this brief article. Instead, I merely suggest some ideas: First, contrary to simplistic technological determinist views, technological change is more than just invention and innovation. It also involves the manner in which science and engineering knowledge get applied. The entire process is fundamentally social in character, which means that it is not natural or value free. Second, particularly in the contemporary world, knowledge and technological innovation are produced by an organized R&D industry. This requires elaborate and expensive infrastructures: sophisticated laboratories, legions of highly trained specialists, and extensive education systems. The associated costs may make competitive R&D activities difficult, or even impossible, in all but the most wealthy advanced societies. Third, in the late twentieth century, two types of large institutional actors tend to lie behind most technological development: large corporations and governments. The most effective advanced centers of technological development are the result of a massive mobilization of human and capital resources possible only through extensive cooperation between states and multinational companies. These institutions are most likely to be located and controlled by corporate and government interests in the advanced core states.

This suggests that the appropriate units of analysis with which to discuss technological changes are the world-economy and the international system. However, here it is important to emphasize my conception of the world-system. It is most definitely *not* one in which national boundaries and states are becoming irrelevant; quite the contrary. Worthington (1991) provides a useful overview of the globalization of production. This involves the emergence of a new international division of labor (NIDL), gradually shifting global manufacturing from core nations to peripheral countries (Fröbel, Heinrichs, and Kreye 1980). Accompanying this shift are the diffusion of Western ideology and social organization and all the attendant problems of industrialism and consumerism. Culturally the world becomes, to use Marshall McLuhan's terminology, "a global village." However, the claim that "the national boundaries demarcating the political loyalties of the earth's inhabitants have little relevance to many new developments in the cultural, economic, and technological spheres of the modern world" (Worthington 1991, 17) misses an essential (if ironic) element of globalization. The new,

more tightly integrated world division of labor has emerged precisely *because* we live in an inter*national* system with very salient political boundaries. The global strategy of multinational capital is designed to exploit those boundaries and the very different legally and socially institutionalized economic opportunities they offer. Uneven development and immense levels of international inequality are crucial components of the NIDL. Global firms and investors seek to maximize profits by locating production where costs for labor, raw materials, environmental or safety regulations, management amenities, or social overhead (taxes) are low. The international system fragments labor into national working classes and sets Third World states into competition against each other for foreign investment. Some of the most pressing problems that global industrial capitalism conjures up—like the specters of environmental destruction or thermonuclear catastrophe—will not respect national borders. But those boundaries are crucially important for understanding the uneven distribution of resources on the planet.

Technological expertise is one such resource. It tends to be controlled by the core-based multinational corporations and the states of the advanced industrial countries (especially in these nations' "military-industrial complexes"; see Noble 1985; Mukerji 1989). One of the real dilemmas of dependent development, particularly of the middle-level semiperipheral societies, involves the way their governments and businesses handle the issue of technology.

Recently, my research has focused on South Korea (Smith and Lee 1990). Korean government planners are acutely aware of the need to develop "science and technology capacities." In a 1988 interview, a planner at the Korean Institute for Economics and Technology (KIET) told me that "developing independent technology" and moving toward "capital-intensive production" are the keys to keeping the South Korean economy "truly internationally competitive" (interview with Dr. Kang Won Lee, 14 July 1988). In a published review of industrial policy, another KIET research fellow notes various steps under way to encourage the development of new technology (through direct government support and tax incentives) (Kang 1988). Between 1980 and 1986, R&D investments as a share of gross national product (GNP) rose from 0.9% to 2%, "which is almost the OECD level" (Kang 1988, 31), with plans to increase it to 3% by the early 1990s (Kang 1988, 37). Moving to high-technology industry is seen as a way to move the Korean economy past the stage where profits and productivity are still largely dependent on labor repression and low wages. And there is near consensus among the South Korean development planners, academic planners, and political advisers with whom I spoke in 1988 that the social costs of low-wage export-oriented manufacturing had become politically intolerable. There is

a growing perception that working-class acquiescence to "labor discipline" is over—industrial workers seem no longer willing to accept low wages and restricted consumption as a price for "national development" (see Deyo 1989).

But the obstacles to developing independent technology are great. Korean firms continue to rely on the "cooperation" of U.S. and Japanese corporations. And many of these firms are quite reluctant to engage in " 'real' technology transfer." As a result, "backward engineering" is still the rule, in which products from the advanced industrial nations are stripped down so Korean firms can learn how to copy them. Of necessity, this type of R&D relegates the economy to a lower swing of the "product-cycle" than nations that are the true innovators (see Cumings 1984 for a discussion). Haggard and Cheng (1987) claim that the key to sustaining economic growth is "the development of an indigenous capacity for science and technology." But the Korean education system, although excellent by Third World standards, is quite backward compared to that of the United States, Japan, or Western Europe. Libraries and laboratories (even at the highest-ranking Seoul universities) are the most obvious indicator, often lacking the latest books and scientific equipment. This relative lack of educational infrastructure will make advanced R&D very difficult.

This disadvantage helps persuade me that, optimistic projections to the contrary, South Korea is not likely to move into the ranks of advanced industrial core nations anytime soon. In this regard, South Korea is just an example. Other large semiperipheral states (Brazil, Taiwan, Mexico, etc.) face similar dilemmas (e.g., for an interesting comparative analysis of the development and application of computer technology in Brazil and Korea, see Evans and Tigre 1989). And the South Koreans actually seem to be considerably *ahead* of other newly industrializing countries (NICs) in R&D expenditures, spending over twice the average percentage of total GNP for all developing countries (United Nations 1987b, 79, Table 26). Other semiperipheral NICs doubtlessly have *less* capacity for technological innovation and development than South Korea does.[2]

Clearly, the control over technology and the process of technological innovation is a critically important element in the contemporary capitalist world-economy. It is the key to high rates of profit for giant transnational firms and a linchpin in the maintenance of global inequality. Therefore, it is somewhat surprising that international political economy research has failed to incorporate the insights and agendas of serious research on the process by which scientific knowledge is produced, disseminated, and controlled. (Vaitsos's [1974] research on the international control of technological patents and licenses may be a partial exception.) Clearly, science and tech-

nology are globalized in the late twentieth century—and the locus of innovation and control lies in the well-funded advanced research and engineering institutes, universities, and laboratories of the advanced core countries of the United States and Western Europe (as Schott [1988] documents so well).

The world-system perspective has failed to arrive at a theory of the organizational dynamics of science and technology as a global system. But differential control of technology and capacity for technological innovation are defining traits of the subordination and dependency in contemporary noncore countries—even when those nations are newly industrialized or semiperipheral. A more complete understanding of the development of science and technology in the global system would not only be of interest to comparative social scientists; it could also help planners and policymakers solve some of the real-life "dilemmas of development."

Notes

1. Another U.N. document provides further evidence of the unequal expenditures on technological research:

> levels of R and D in the United States and certain Western European countries amounted to about $200 per capita, while the corresponding figure for Latin American countries was less than $5 per capita and that for poorer countries in Africa and Asia was less than $1" (United Nations 1987a, 8-9).

2. One anonymous reviewer for *Science Technology & Human Values* pointed out that Third World nations, whether they are semiperipheral or peripheral, may choose not to develop "like us" and, instead, seek a more sustainable alternative strategy. Citing Ivan Illich (1978), this reviewer suggested that the countries of the South may attempt to "repossess" and "refashion" science and technology to meet the vast needs of their own people that are currently unmet. I believe that it is important to acknowledge this possibility and to encourage Third World peoples to explore these sorts of creative alternative trajectories. But the reality of globalizing science and technology in an increasingly tightly integrated capitalist world-system probably leaves fairly limited "breathing space" for the nurturance of such alternative models. At the very least, the designers of different strategies will need to understand the dominant logic of the global system, if only to decide how to evade it.

References

Arrighi, Giovanni, and Jessica Drangel. 1986. The stratification of the world-economy: An exploration of the semiperipheral zone. *Review* 10(1): 9-74.

Chase-Dunn, Christopher. 1980. The development of core capitalism in the United States: Tariff policies and class struggle in an upwardly mobile semiperiphery. In *Studies of the modern world system*, edited by Albert Bergesen, 189-230. New York: Academic Press.

———. 1988. *Global formation: Structures of the world-economy*. New York: Blackwell.

Cumings, Bruce. 1984. The origins and development of the northeast Asian political economy: Industrial sectors, product cycles, and political consequences. *International Organization* 38:1-40.

Deyo, Frederic. 1989. *Beneath the miracle: Labor subordination in the new Asian industrialism*. Berkeley: University of California Press.

Dicken, Peter. 1992. *Global shift: The internationalization of economic activity*. 2d ed. New York: Guilford.

Evans, Peter, and Paulo Tigre. 1989. Paths to participation in "hi-tech" industry: A comparative analysis of computers in Brazil and Korea. *Asian Perspective* 13(1): 5-35.

Freeman, C. 1987. *Technology policy and economic performance: Lessons from Japan*. London: Pinter.

Fröbel, Volke, Jurgen Heinrichs, and Otto Kreye. 1980. *The new international division of labor*. London: Cambridge University Press.

Gereffi, Gary. 1983. *The pharmaceutical industry and dependency in the Third World*. Princeton, NJ: Princeton University.

Haggard, Steven, and Tun-jen Cheng. 1987. State and foreign capital in East Asian NICs. In *The political economy of the new Asian industrialism*, edited by Frederic Deyo, 84-135. Ithaca, NY: Cornell University Press.

Henderson, Jeffrey. 1989. *The globalisation of high technology production: Society, space, and semiconductors in the restructuring of the modern world*. New York: Routledge.

Illich, Ivan. 1978. Outwitting developed nations. In *Toward a history of needs*, 54-67. Berkeley, CA: Heyday Books.

Kang, Chul Kyu. 1988. *Industrial policy in Korea: Review and perspective*. Seoul: Korea Institute for Economics and Technology.

Lenski, Gerhard. 1976. History and social change. *American Journal of Sociology* 82:548-64.

Lenski, Gerhard, and Jean Lenski. 1987. *Human societies: An introduction to macrosociology*. 5th ed. New York: McGraw-Hill.

Mukerji, Chandra. 1989. *A fragile power: Scientists and the state*. Princeton, NJ: Princeton University Press.

Noble, David. 1985. *Forces of production: A social history of industrial automation*. New York: Oxford University Press.

Organization for Economic Cooperation and Development. 1986. *Selected science and technology indicators: Recent results, 1979-1986*. Paris: OECD.

Porter, Michael. 1990. *The competitive advantages of nations*. New York: Free Press.

Portes, Alejandro. 1976. On the sociology of national development. *American Journal of Sociology* 82:3-38.

Reich, Robert. 1991. *The work of nations: Preparing ourselves for 21st century capitalism*. New York: Alfred A. Knopf.

Romer, Paul. 1990. Endogenous technological change. *Journal of Political Economy* 98:S71-S102.

Roobeek, A.J.M. 1990. *Beyond the technology race: An analysis of technology policy in seven industrial countries*. Amsterdam: Elsevier.

Schott, Thomas. 1988. International influence in science: Beyond center and periphery. *Social Science Research* 17:219-38.

Schumpeter, Joseph. 1964. *Business cycles: A theoretical, historical, and statistical analysis of capitalist process*. New York: McGraw-Hill.

Smith, David and Su-Hoon Lee. 1990. Limits on a semiperipheral success story? State dependent development and the prospects of South Korean democratization. In *Semiperipheral states in the world-economy*, edited by William Martin, 79-95. Westport, CT: Greenwood.

Toffler, Alvin. 1971. *Future shock*. New York: Bantam.

Toffler, Alvin, and Heidi Toffler. 1990. *Power shift: Knowledge, wealth, and violence at the edge of the twenty-first century*. New York: Bantam.

United Nations. 1987a. *Revitalizing development, growth and international trade*. New York: Author.

———. 1987b. *Trade and development report*. New York: Author.

Vaitsos, Constance. 1974. *Intercountry income distribution and transnational enterprise*. London: Oxford University Press.

Wallerstein, Immanuel. 1974. *The modern world-system, I*. New York: Academic Press.

———. 1980. *The modern world-system, II*. New York: Academic Press.

———. 1989. *The modern world-system, III* New York: Academic Press.

Worthington, Richard. 1991. The nature of global processes. In *New worlds, new technologies, new perspectives*, edited by S. Cutliffe and S. Goldman. Bethlehem, PA: Lehigh University Press.

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